First Stars and Black Holes

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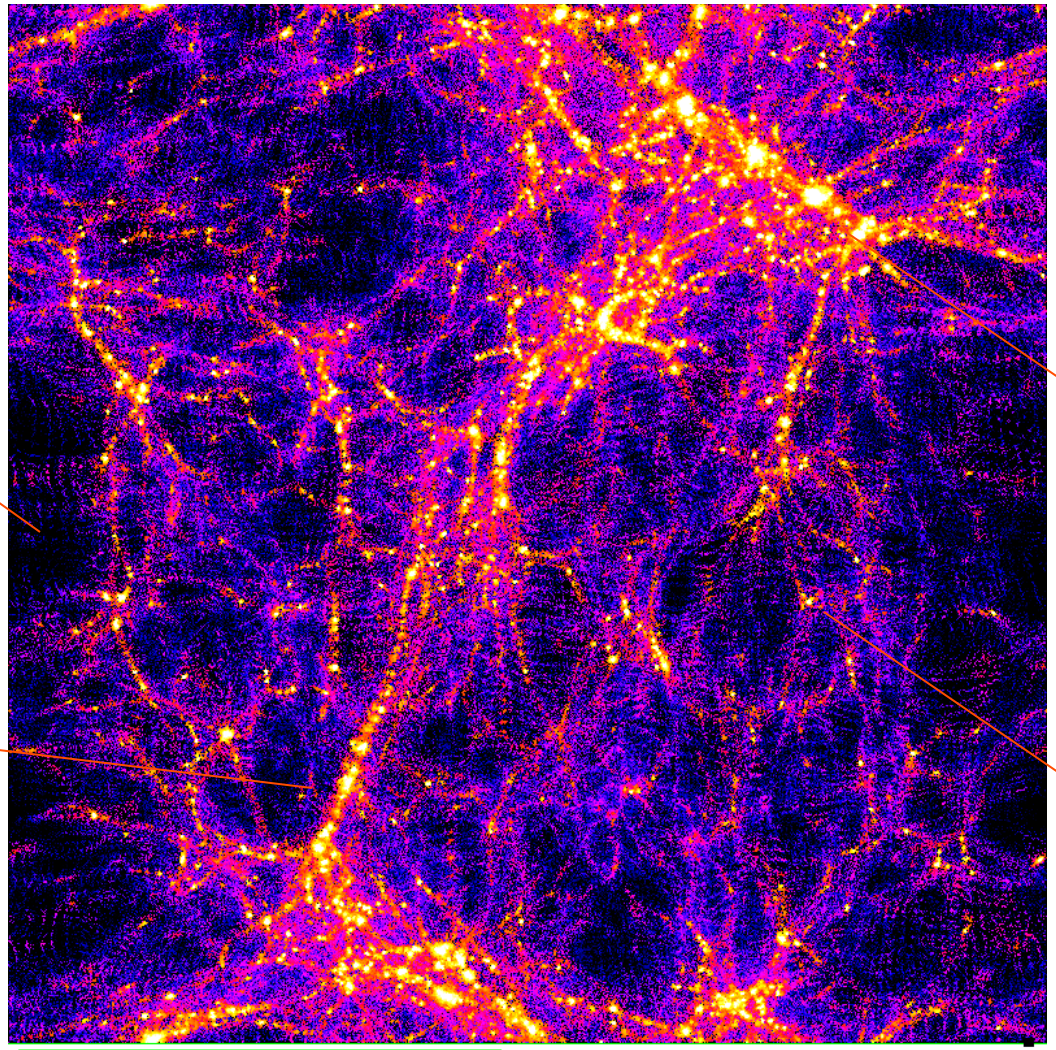
$\Omega_\Lambda = 0.73, \Omega_m = 0.27, h = 0.71; z = 10; M_{min} = 10^5 M_\odot$



Voids

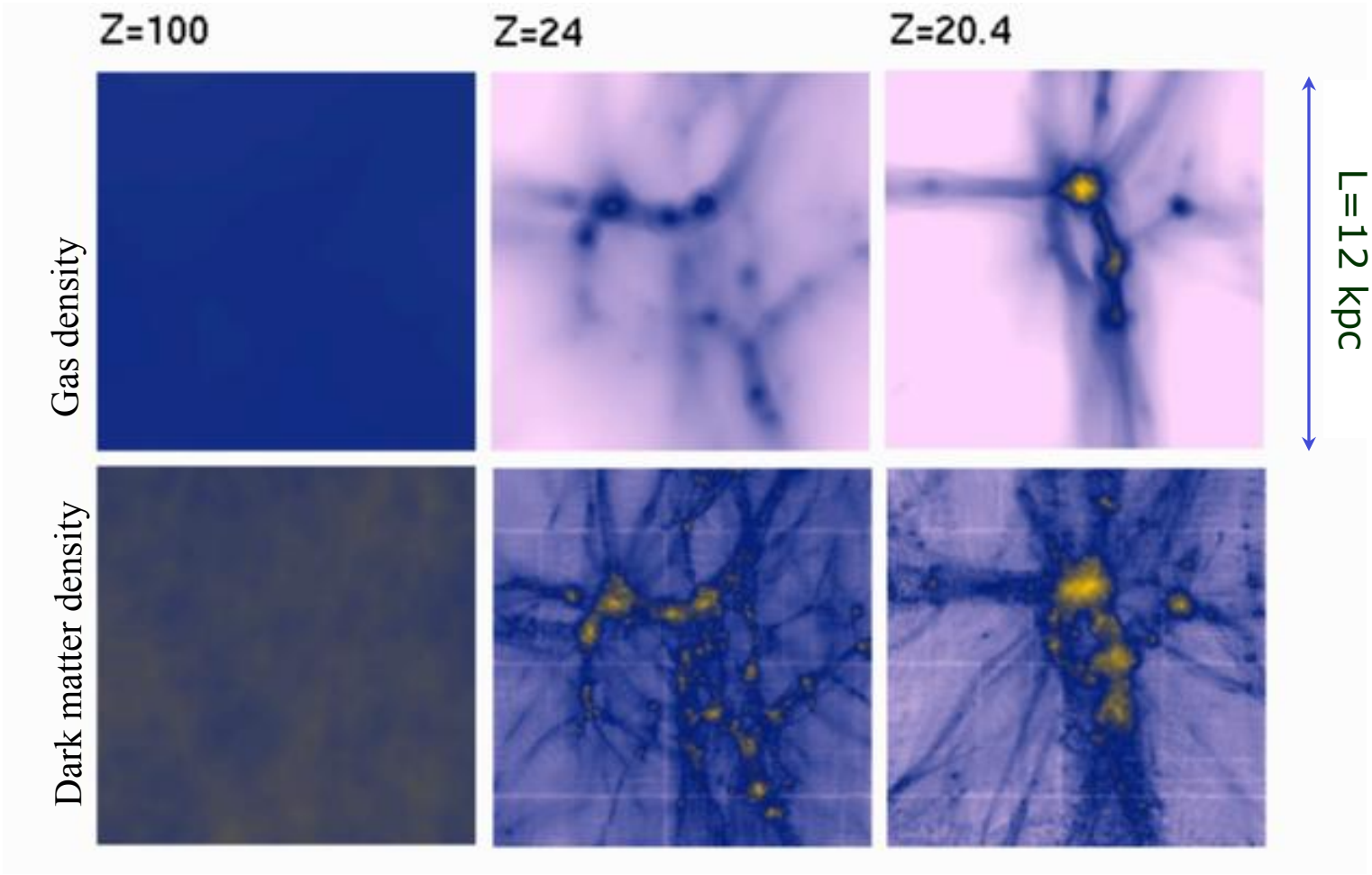
Filaments

Galaxy Cluster

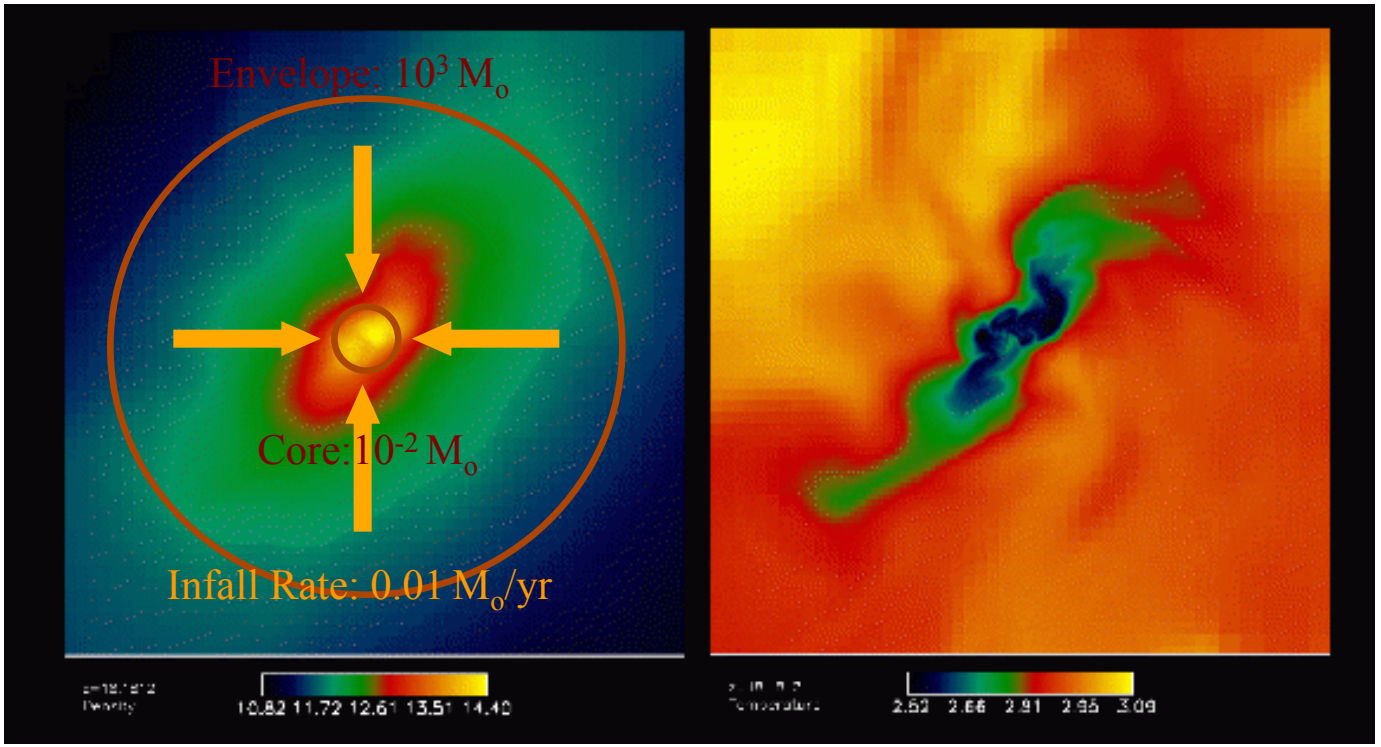
First Objects

$L = 1\ h^{-1}\ cMpc$

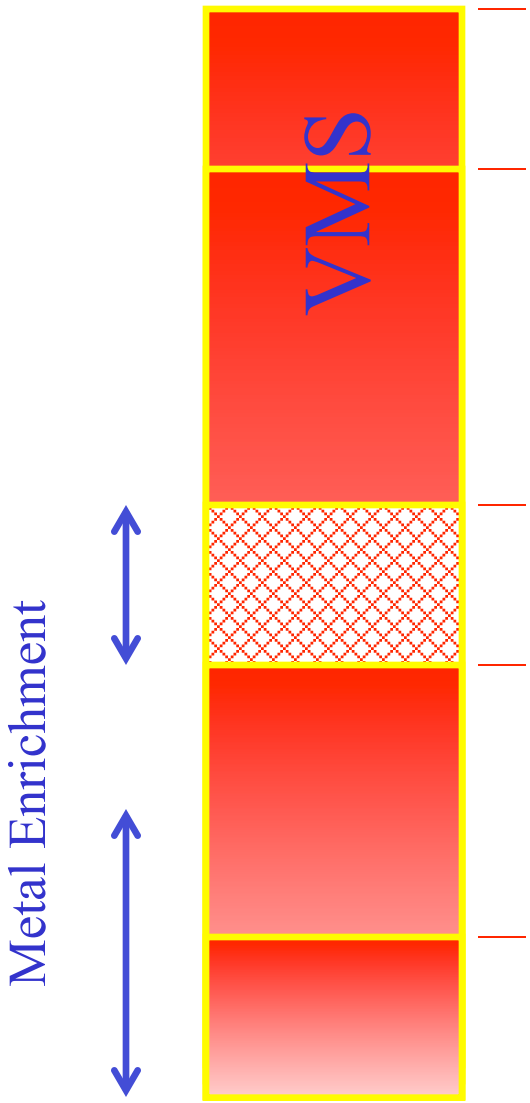
COLLAPSE



FIRST STARS ARE MASSIVE



Density Temperature

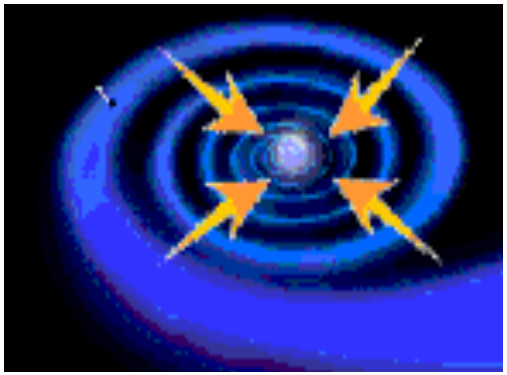


$10^6\ M_\odot$

$10^5\ M_\odot$

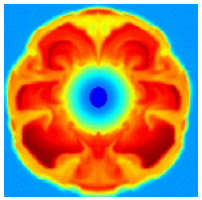
IMBH

GRBs ?



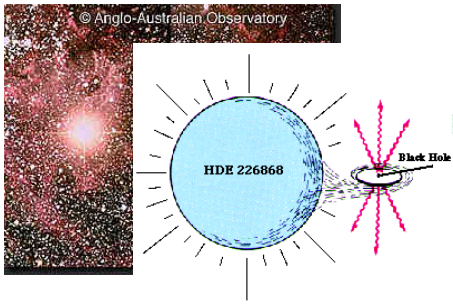
$260\ M_\odot$

PISN



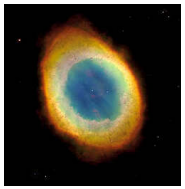
$140\ M_\odot$

NS/BH



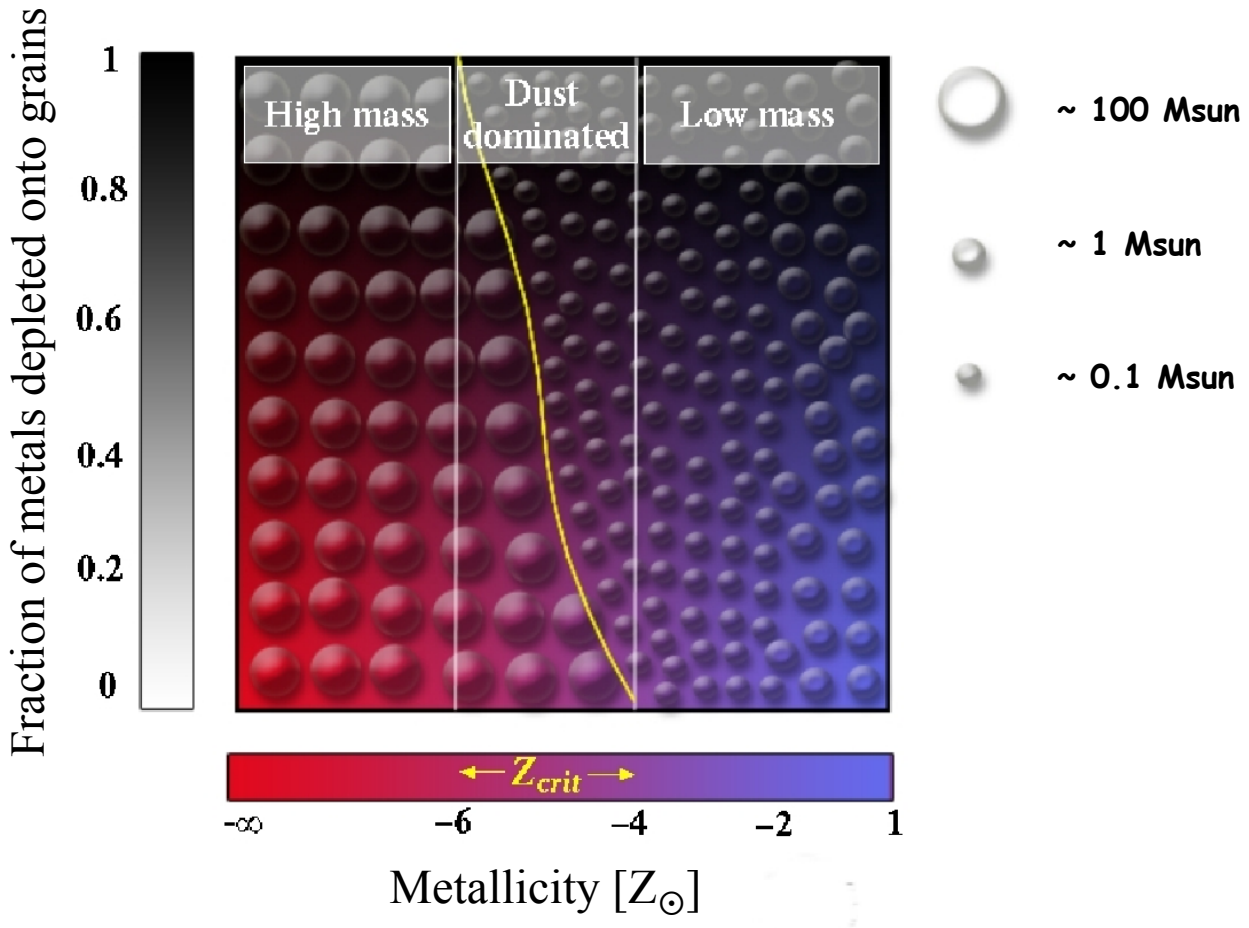
$8\ M_\odot$

PN



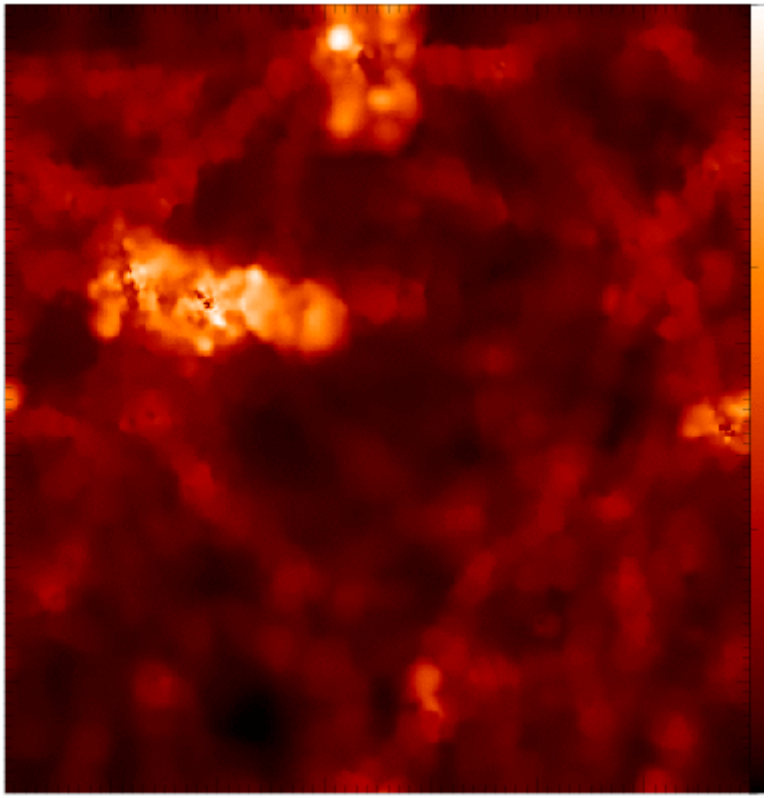
Schneider+2005

OVERVIEW

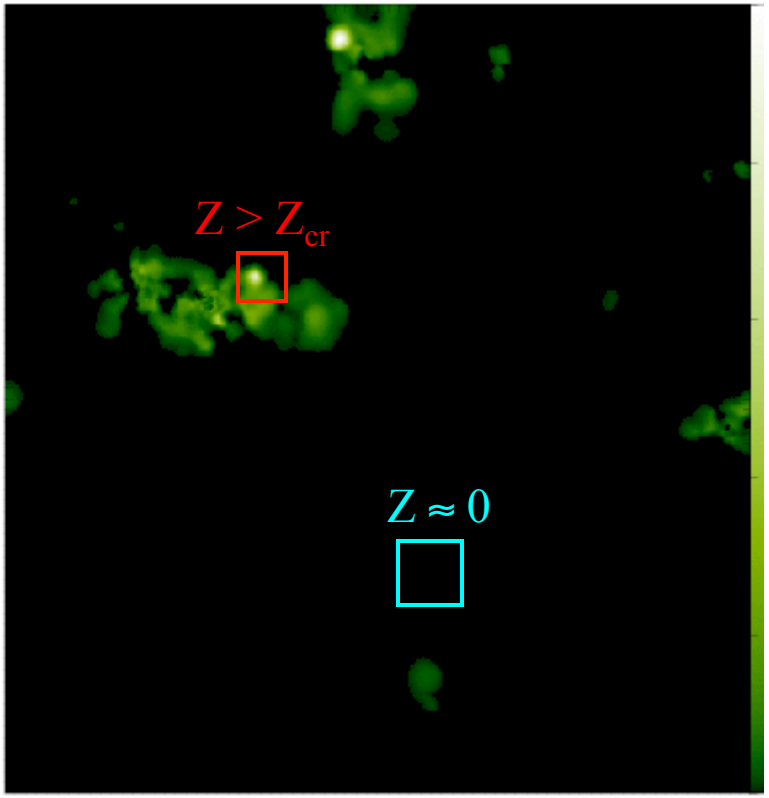


Dayal+2010

THE IGM AT Z=6



Gas Density



Metallicity

MINIQUASARS

Salvaterra+05

Intermediate Mass Black Holes, shining as miniquasars, might contribute substantially to reionization photon budget

Miniquasars will contribute also to the Soft X-ray Background (0.5-2 keV) that is now resolved to ~94% level (discrete sources at z<4)

STRONG UPPER LIMIT

Unresolved fraction $< 1.23 \times 10^{-12}$ *erg* s^{-1} *cm*$^{-2}$ *deg*$^{-2}$

Moretti+2003; Dijkstra+2004

MINIQUASAR SPECTRA

TWO COMPONENT SPECTRUM

Multi-Color Disk: L_{MCD}

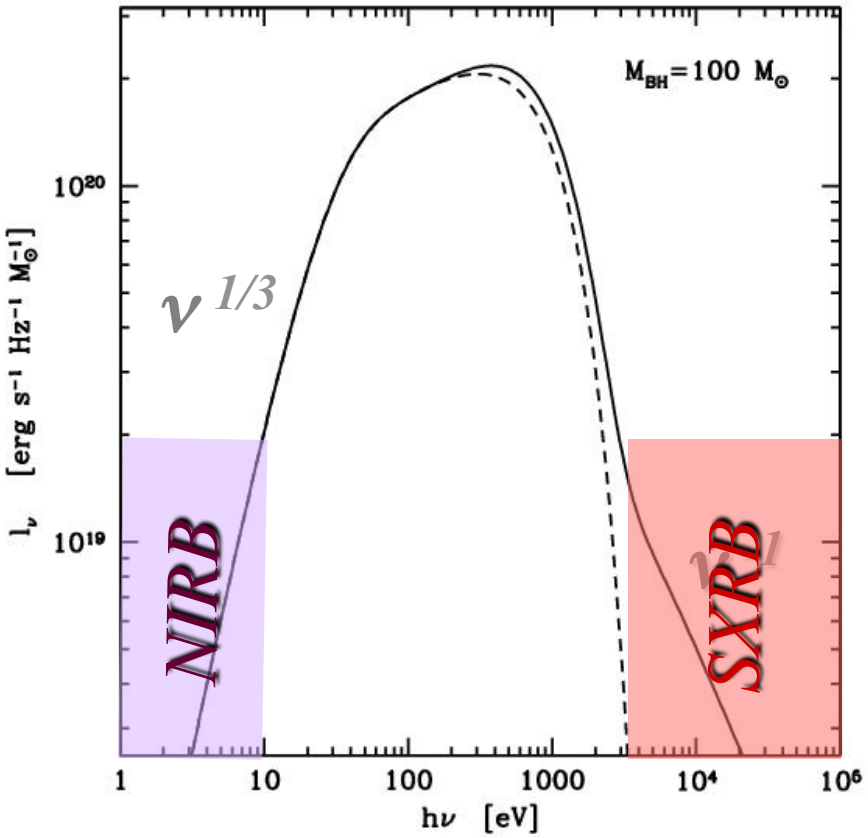
Multi-temperature BB accretion disk.
Spectrum peaked @ $E_{peak}=3kT_{max}$

Power Law: L_{PL}

$L_{\nu,PL} \propto \nu^{-1}$ for $E>E_{peak}$

IC scattering of thermal disk photons

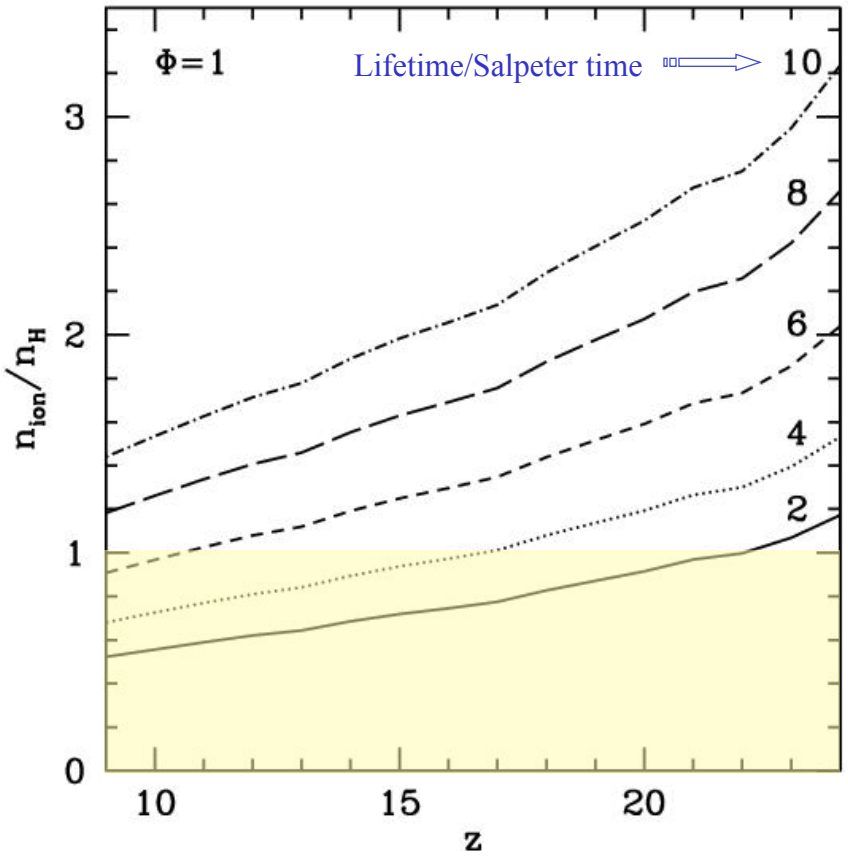
$$\Phi = \frac{L_{PL}}{L_{MCD}} \approx 1 \quad \text{for ULX}$$



CONSTRAINTS FROM SXRB

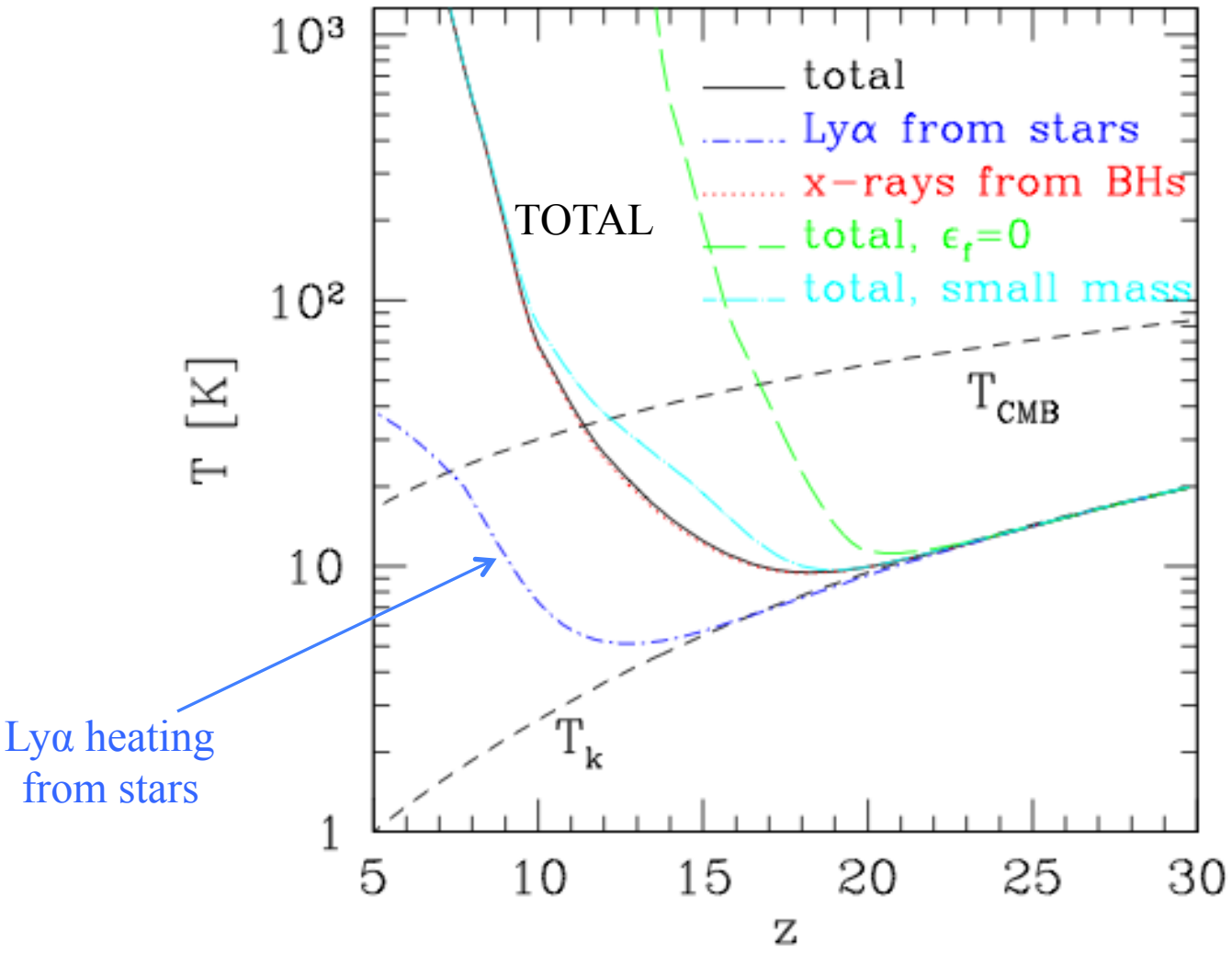
Salvaterra+05

Ionizing Photons from IMBHs



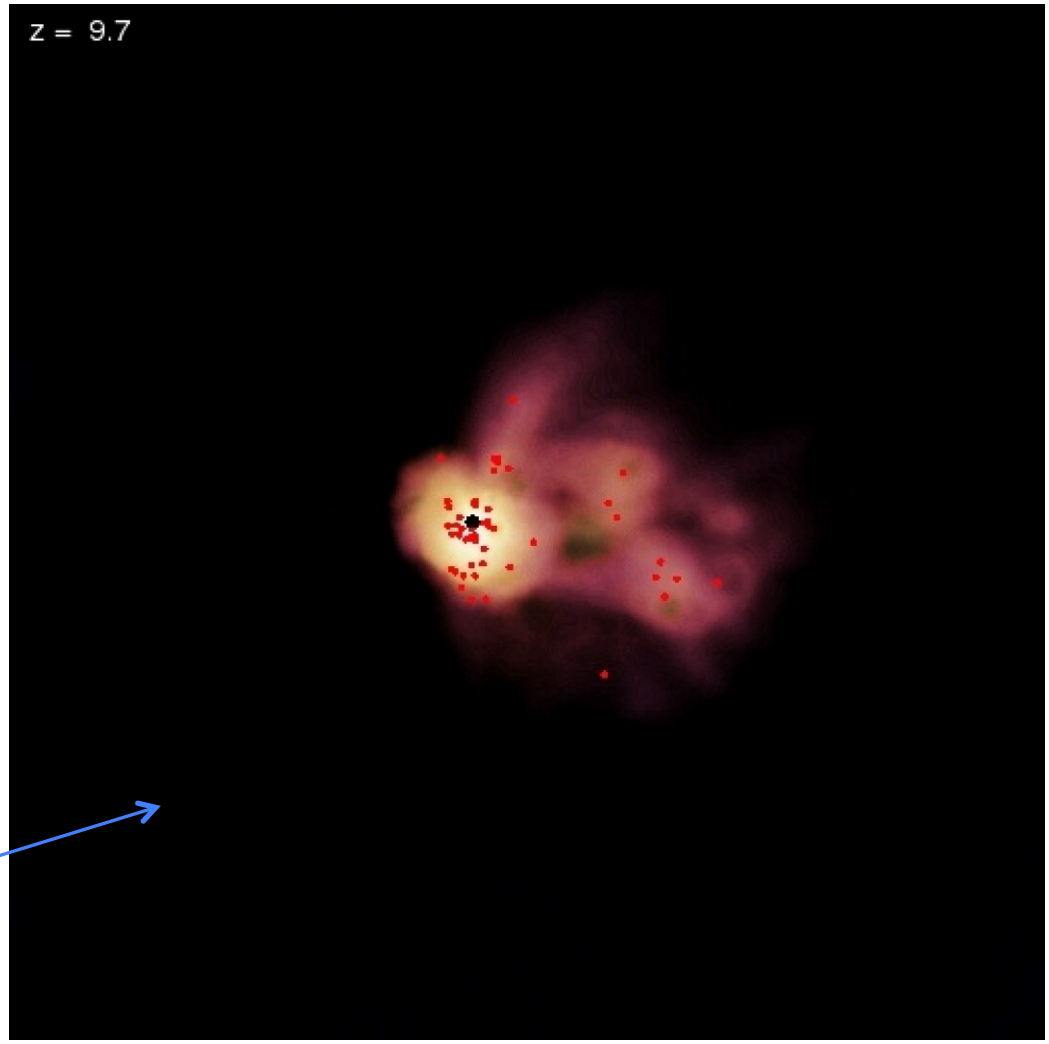
SPIN TEMPERATURE EVOLUTION

Ciardi+09



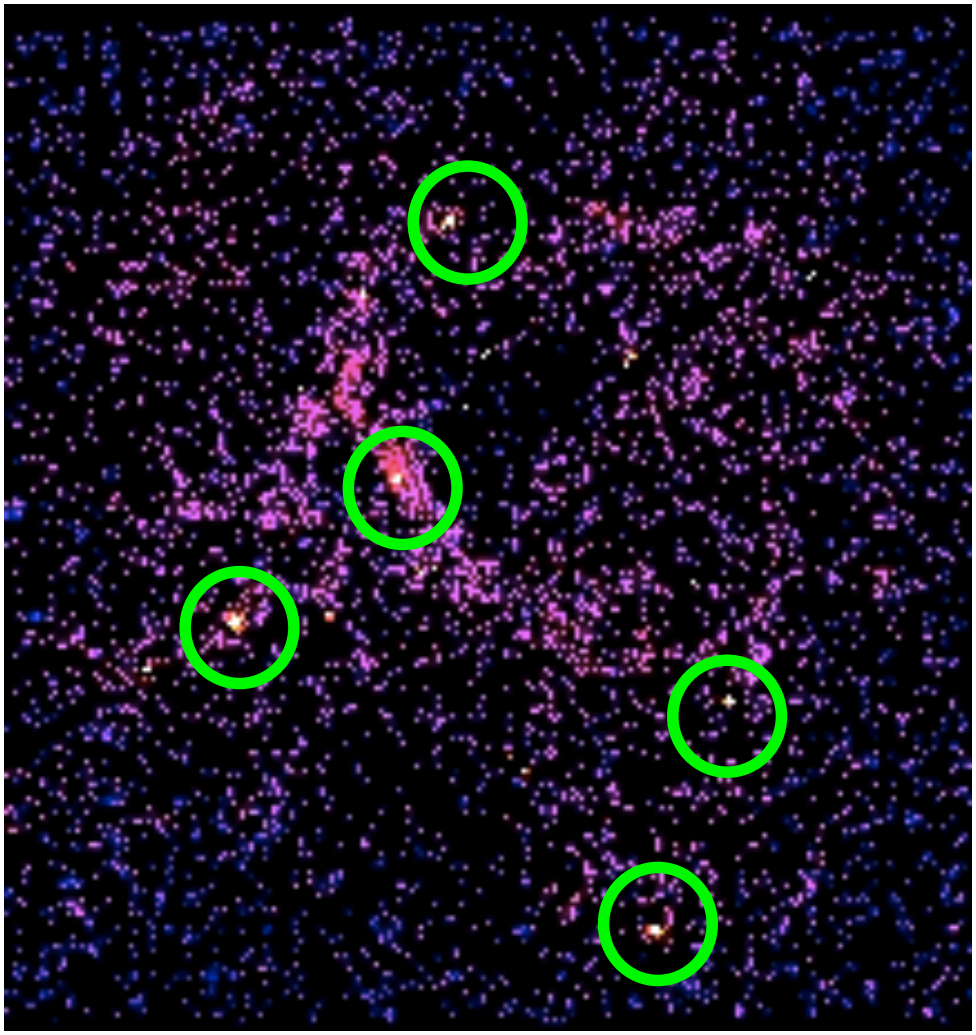
GROWTH

Peloupessy+07



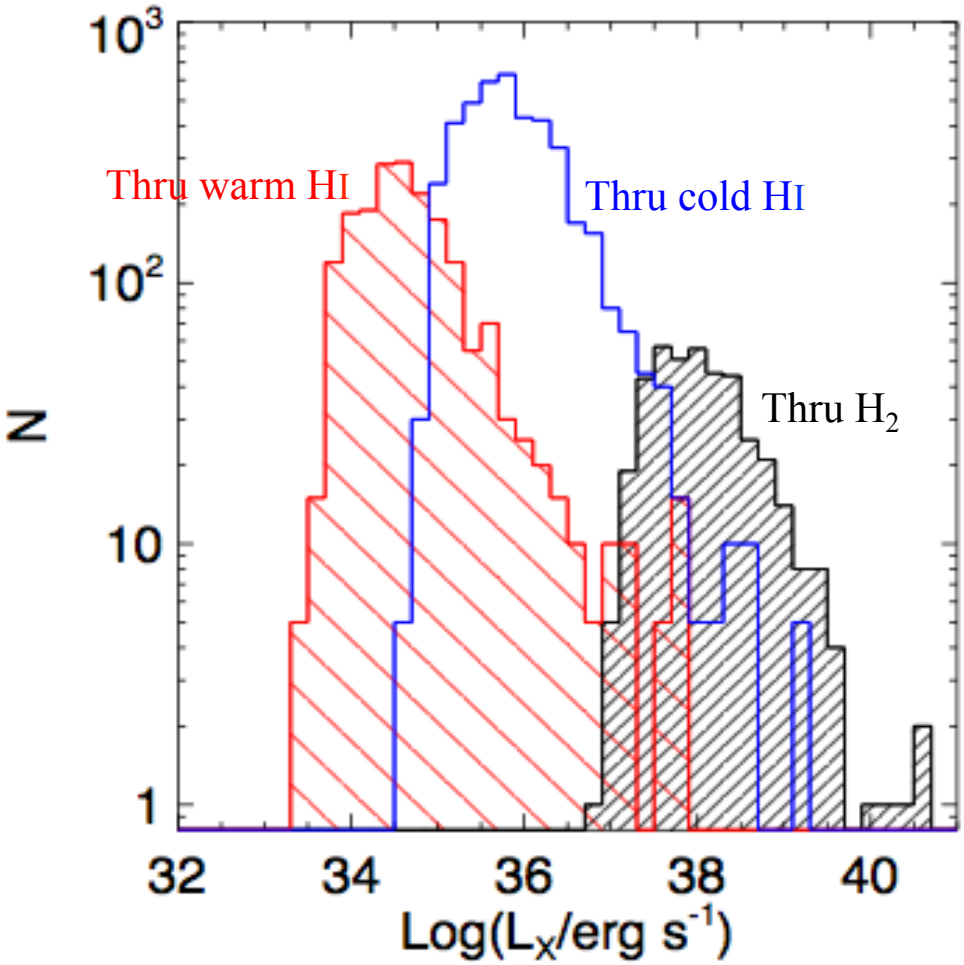
Mapelli, AF & Rea 2006

IMBHs THROUGH THE MILKY WAY



Mapelli, AF & Rea 2006

IMBH X-RAY LUMINOSITY FUNCTION



PRESENT-DAY IMBH DENSITY

Accretion Mode

DM Halo Profile

	ADAF DISK	THIN DISK
NFW	$< 10^{-1}\ \Omega_b$	$< 10^{-2}\ \Omega_b$
DMM	$< 10^{-2}\ \Omega_b$	$< 10^{-3}\ \Omega_b$

Constraints on $\Omega_\bullet$

SELECTED SUMMARY

- First stars are massive, $M > 100\ M_{\odot}$: die as PISN or collapse to IMBH
- PISN (and later SN) provide the (early) observed IGM metal enrichment
- Transition to normal stars occurs whenever/wherever $Z = Z_{crit} \sim 10^{-5}\ Z_{\odot}$
- Leave strong signature in the redshifted HI 21 cm line power spectrum
- IMBH can continue to form down to moderate redshifts.
- Likely the seeds of Supermassive Black Holes detected at z>6
- IMBHs current density constrained by ULXs: $\Omega_{\bullet} < 0.1\ \Omega_{b.}$ Observable with IXO ?